REFRACTORIES FOR GLASS PRODUCTION

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EXPERIENCE OF THE SARATOV INSTITUTE OF GLASS IN DEVELOPING SPECIAL-DUTY REFRACTORIES FOR FLOAT PROCESS

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The Saratov Institute of Glass has developed a domestic version of the float process using two-stage formation of glass and is one of the leaders of applied research in Russia in the field of production and development of new different types of float glass and products based on this glass.

The Saratov Institute of glass was founded in 1960 as a branch of the State Institute of Glass (GIS) and is currently one of the leading applied research centers in Russia successfully functioning in the field of production and development of various new types of float glass and products based on this glass.

The Saratov Institute of Glass has developed the domestic float-glass technology involving two-stage glass formation; it has developed heat-absorbing tinted float glass, electrochemically tinted glass, as well as the Ritm and Metelitsa decorative glass. The institute uses it own float-glass line to produce heat-absorbing glass of diverse colors and thickness, as well as decorative glass with corrugated or figured surface.

The principle of the float process is the formation of a glass ribbon upon metallic melt in the melt tank, which constitutes an enclosed metallic shell lined by refractory materials and is one of the critical machinery items in the technological line. The requirements on refractories for the melt tank differ from traditional requirements on refractories for glass-melting furnaces or furnaces producing metallic tin, since the former ones operate in contact with tin, tin vapor, and tin oxide in a hydrogen-bearing atmosphere. Research on refractories capable of serving in a melt tank was started in 1965 based on the experience of the metallurgical sector. Several companies, including the East Refractory Institute, studied the behavior of different refractory materials in contact with tin, but none of those was recommend for the melt tank.

The target of the Laboratory of Refractories at the Saratov branch of the GIS institute was to provide refractories for the new float-glass process. By the end of 1967 all known refractories had been tested on specially designed test plants. Based on the research performed and the analysis of refractory production in Russia and the industrial experience, the following main criteria for estimating the suitability of refractories for melt tank lining in a float-glass line were formulated:

– materials for the tank bottom lining should be durable under long-term service in the interval of 600 – 1000°C in a hydrogen-bearing medium in contact with tin and its oxides and should not form reaction products at the refractory – hydrogen or refractory – metal (oxide) contact interface that could impair the quality of glass;

– the chemical composition of the refractory (content of Al_2O_3, Na_2O, K_2O, Fe_2O_3, and SiO_2) depends of the main requirements on its properties, since they depend on the chemicomineralogical composition and structure of refractory products;

– refractory materials should have a structure ensuring minimal permeability for hydrogen, the melt, and metal oxide vapors (the controlled parameters include apparent density, porosity, gas permeability coefficient, and channel porosity);

– refractories should have sufficient thermal resistance and thermal conductivity to ensure the required temperature in tin during the production of polished glass; the mean thermal conductivity of refractories should not exceed $1.36\ \text{kcal}/(\text{m} \cdot \text{h} \cdot \text{K})$ at any temperature up to 800°C;

– refractories should have a constant volume or an insignificant volume increase as the refractories are heated to the service temperatures;

– since the metal (tin) melt has high fluidity, the brickwork of the tank bottom should have the least possible number of joints; consequently, such refractories should be produced as large-size blocks;

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– refractories should be inexpensive, have sufficient mechanical strength to resist the ramming tool loads and multiple displacements in the course of installation of the melt tank lining while preserving the integrity of edges, etc.

To impart the required properties to the melt tank refractories, special research was carried out to identify materials for bottom bars and roof beams, refractory mixtures and concretes, which were tested on special test benches and semi-industrial plants before industrial application. The main class of refractories found suitable for serving in a melt tank were aluminosilicate refractories.

Since the properties of refractories to a large extent depend on the initial raw materials, the Saratov Institute analyzed and identified the requirements on raw materials. For chamotte refractories the main material is clay; accordingly, we not only identified the required content of the main material but also prescribed the presence of undesirable impurities in clay impairing its refractoriness, namely, compounds of iron, calcium, magnesium, sodium, and potassium, as well as silica, which causes loosening in firing under high temperatures. Thus, not only requirements on the chemical composition of refractories, but on the composition of initial materials as well, have been formulated.

Based on this research, the Saratov Institute has developed critical requirements on materials for the melt tank and compiled a list of them; later the following refractory materials have been produced and successfully operated:

– for the melt tank bottom — a two-layer composite consisting of chamotte refractory containing 33 – 36% Al_2O_3 and corundum concrete with an aluminophosphate binder as coating (later the idea of using concrete for coating was abandoned, since chamotte refractories in the bottom of the melt tank withstand without replacement 2 – 3 shutdowns during cold repairs of the glass-melting furnace and remain sufficiently technologically effective and resistant to aggressive media). The first chamotte bars for the melt tank bottom were produced at the Ulan-Ude Glass Works, later this technology was implemented at the Borskii, Saratosvkii, Salavatskii, Tokmakskii and other glass factories;

– a fire-free chamotte-zircon mixture was developed for sealing fastener holes in chamotte bars and sealing spaces between the refractory and the metallic shell of the tank, and corundum concrete based on water glass filling the space between the tank case and the refractory was developed for protecting the bottom fastening nut and the stud to avoid the penetration of tin;

– a user manual has been developed for preparing, testing, and using ramming mixtures and concrete at a glass factory;

– refractories for the melt tank roof — suspended complex-configuration beams and ceiling plates; these are high-alumina items that are produced at the Semilukskii Refractory Works;

– for the glass melt discharge unit — Bacor-33 electromelted baddeleyite-corundum refractory produced at the Saratov Works of Technical Glass; special rigging has been designed for attaining good quality of mechanical treatment of products;

– for the gates — initially a chamotte refractory was proposed; later quartz ceramics (the technology for producing gates was developed by the GosNIIKS Institute).

The Saratov Institute of Glass was the first to develop a full set of technical specifications for the production and application of special refractory materials and products for the melt tank; serial production of refractories for the melt tank has been implemented under the guidance of the researchers from the said institute.

Long-term service of melt tanks lined by domestic refractories has been recorded. For instance, LDF-1 and LDF-2 lines (Saratovstroisteklo) have served 13.5 and 16 years, respectively. The refractories in the melt tank of the float-glass line of the Saratov Institute of Glass have served nearly 24 years in the extreme conditions of experimental research and continuous renewal of the glass product range and have withstood three shutdowns for cold repairs of the glass-melting furnace. The investigation of melt tank lining during reconstruction works at the above and many other float lines, which was performed during reconstruction works, demonstrated high service the parameters of this chamotte. At present the installation of melt tanks lining and its cooling or heating to service conditions at Russian glass factories are implemented during cold repairs and construction of new float lines in accordance with recommendations issued by the Saratov Institute of Glass.

The research on refractories carried out over 30 years ago has not lost its relevance, since refractories recommended at that time are still in service and their requirements are determined by the specified criteria.

At present the researchers at the Saratov Institute of Glass together with the Semilukskii Refractory Works are investigating the suitability of the new generation of refractories (concretes) for the melt tank lining.

The Saratov Institute of Glass also lends qualified assistance in selecting refractories, implementing cold repairs, bringing the melt tank to the operating regime, and issuing user instructions and technical standards for melt tanks. The institute has participated in the development, installation, and start-up of nearly all float lines in Russia and neighboring countries including the new lines in Gomel and Kuvasai.